

# Radiation Belt Storm Probes (RBSP) Education and Public Outreach Program

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**Abstract** The Radiation Belt Storm Probes (RBSP) Education and Public Outreach (E/PO) program serves as a pipeline of activities to inspire and educate a broad audience about Heliophysics and the Sun-Earth system, specifically the Van Allen Radiation Belts. The program is comprised of a variety of formal, informal and public outreach activities that all align with the NASA Education Portfolio Strategic Framework outcomes. These include lesson plans and curriculum for use in the classroom, teacher workshops, internship opportunities, activities that target underserved populations, collaboration with science centers and NASA visitors' centers and partnerships with experts in the Heliophysics and education disciplines. This paper will detail the activities that make up the RBSP E/PO program, their intended audiences, and an explanation as to how they align with the NASA education outcomes. Additionally, discussions on why these activities are necessary as part of a NASA mission are included. Finally, examples of how the RBSP E/PO team has carried out some of these activities will be discussed throughout.

**Keywords** Education · Outreach · Radiation Belt Storm Probes · NASA · STEM · Space weather · Van Allen

## 1 Introduction

Education and Public Outreach (E/PO) efforts have long been a significant aspect to NASA Science Mission Directorate missions and have been used to inspire, engage and educate Americans with mission science and NASA's mission objectives. Although shifts in policy have at times both decreased and increased the role of E/PO within specific missions, the current guiding principle is to devote a small percentage (about 1 %) of mission funds, excluding launch costs, to support E/PO activities and efforts. With this in mind, the Radiation Belt Storm Probes (RBSP) E/PO program has been actively engaged in a robust plan aimed

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at achieving the outcomes highlighted in the NASA Education Portfolio Strategic Framework (NASA 2007).

The goals of E/PO, as specified by NASA, align with a pipeline strategy that first inspires and engages audiences through public outreach and informal education activities, then educates through formal education activities, culminating with training America's future scientists and engineers through higher education activities. Beginning in 2006, NASA committed to pursuing three major education goals (NASA 2010):

- Strengthen NASA and the Nation's future workforce;
- Attract and retain students in Science, Technology, Engineering, and Mathematics (STEM) disciplines;
- Engage Americans in NASA's mission.

The need for pursuing these goals has always been a part of NASA's overall mission. With NASA's founding legislation, the Space Act of 1958, the Agency was directed to expand the human knowledge of Earth and space phenomena and to preserve the role of the United States as a leader in aeronautics, space science and technology (NASA 2010). To achieve this, NASA must utilize some of its resources and invest them in STEM education, ensuring that the United States remains a leader in space exploration and science—not just presently, but throughout future generations as well. Additionally, it is not just for the benefit of producing top-quality scientists and engineers that NASA invests in STEM education, but also to ensure that the Nation is comprised of a scientifically literate electorate.

A report written by the National Science Board in 2004 contained results from a survey concerning Americans' science literacy. This report stated that although Americans express strong support for science and technology, they are not very well informed about these subjects. Furthermore, the Program for International Student Assessment (PISA), sponsored by the Organization for Economic Cooperation and Development (OECD), conducted a global survey of the science literacy of 15-year-old students in 2006. The results of the survey showed that U.S. students consistently scored lower in science literacy than other OECD countries. For identifying scientific issues, U.S. students ranked 18 out of 29 countries; for explaining phenomena scientifically, U.S. students ranked 22; for using scientific evidence, U.S. students ranked 21 (USDE 2008). These results showed an alarming need to achieve better results in STEM education and NASA is dedicated, through education and public outreach programs, to counteract the decrease in science literacy currently experienced by the United States. To date, NASA lists over 80 education program opportunities which can be found from the NASA education website <http://www.nasa.gov/offices/education/programs/index.html>. RBSP is a part of the larger Living With A Star program which strives to offer Heliophysics education material and programs for the education community.

Education and public outreach programs are also a useful way to engage NASA and partnering institutions' scientists and engineers with the public as well as the U.S. education system. It's been well documented that scientists face many challenges when communicating their research to the public, especially when dealing with complex systems (Sommerville and Hassol 2011). Education and public outreach programs help to fill the communication gap between scientists and the public and students. With this in mind, it is critical that education and public outreach programs are run not only by education experts, but also by experts in the science and engineering fields. More scientist participation in education and public outreach will ensure that the public and students are engaged with the most up-to-date scientific research and practices. Likewise, scientist participation in the education community will help guide education policy so that today's students are gaining the most effective STEM education for future employment in the STEM workforce (Morrow and Dusenbery 2004).

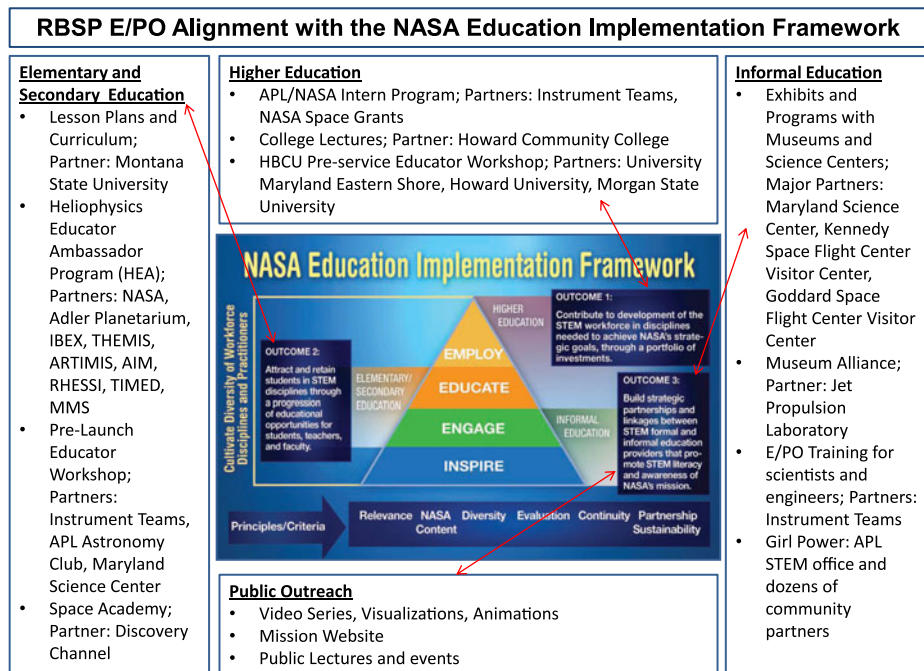
The RBSP mission E/PO program strives to excite and inspire the next generation of space explorers by creating hands-on, minds-on learning experiences for students, educators and the general public. The goal is to make mission science and engineering concepts accessible to a wide range of diverse audiences, including people that may not have necessarily considered themselves to be a part of the science community in the past as well as to those that have some background knowledge, but would like to know more about RBSP. The overarching goal of the E/PO program is to generate excitement and awareness about the mission, highlighting the fundamental science of the Van Allen Radiation Belts, showing how RBSP directly impacts our modern way of life; engaging, and inspiring people to want to know more and perhaps join in the mission's search for answers to the dramatic and puzzling aspects of the Earth's radiation belts.

The various E/PO programs: (1) include collaboration with leading E/PO professionals; (2) ensure alignment with national standards; (3) provide product and activity evaluation; (4) guarantee effective implementation; and (5) create relationships reaching all ages and education levels. The E/PO programs all follow both National Science Education Standards (NSES) (NRC 1996) and NASA Implementation Strategy (NASA 1996), and work closely with NASA's Science Mission Directorate (SMD) E/PO framework and infrastructure, specifically the NASA SMD E/PO Heliophysics Forum. The programs implemented by the RBSP E/PO team are using best practices for professional development, curriculum design and informal education (NRC 1996; NASA 1996; NSB 2004), as well as for involving the scientific community with the program (Morrow and Dusenbery 2004; Buxner et al. 2012). Instrument teams are invited and encouraged to propose and carry out their own E/PO programs under the umbrella of the overall RBSP E/PO program. As part of NASA's education efforts, all of the E/PO programs are designed to be aligned with NASA's Education Portfolio Strategic Framework. The overarching RBSP E/PO program strives to inspire, educate, engage and employ the nation's next generation of explorers (Fig. 1).

E/PO specialists work together with mission and instrument scientists and engineers to create products and activities consistent with the key messages of the mission, while staying true to the needs of diverse audiences. The key mission messages that are addressed within the components of the program are:

- (1) RBSP advances our understanding of the dramatic and puzzling aspects of Earth's radiation belts. The "Van Allen Radiation Belts," named for their discoverer James Van Allen, are two donut-shaped regions encircling the Earth, where high energy particles from the Sun and space are trapped by our planet's magnetic field.
- (2) RBSP enables the prediction of extreme & dynamic space conditions. Changes in the Sun's energy flow cause changes in space. These changes are referred to as space weather and have broad impacts on Earth's systems and inhabitants.
- (3) RBSP provides understanding needed to design satellites to survive in space. RBSP will explore space weather especially its extreme conditions, which can disable satellites, cause power grid failures, and disrupt GPS services.

The E/PO program provides training and materials to teachers to enhance their classroom activities, creates opportunities that directly engage students, and implements events and programs for members of the general public. Additionally, the Radiation Belt Storm Probes E/PO program makes a contribution to the nation's scientific and technical literacy, aligning the materials created specifically for this mission with current national education efforts and standards and addressing identified needs of educators, students, and the public. Components of the RBSP E/PO program are broken down into three categories which are aligned with NASA's Education Goals and Outcomes within the Education Portfolio Framework (see Fig. 1). These categories are:



**Fig. 1** NASA Education Implementation Framework and the RBSP E/PO Approach. E/PO plan aligns with NASA Education Goals and Outcomes. NASA Education Implementation Framework, \*NASA Education Communication Strategy (NP-2008-02-496-HQ) (NASA 2008)

- (1) Formal Education (educating and providing resources for the classroom educator and student),
- (2) Informal Education (inspiring museum and science center attendees) and
- (3) Public Outreach (engaging the public with the mission and engaging scientists with the public).

Each category contains multiple programs designed to inspire, engage, educate and employ the next generation of space explorers. These components lend themselves to a natural pipeline of education and outreach activities; from lesson plans that begin in elementary education, then progress to secondary education, to higher education activities that progress into employment opportunities. They also seek opportunities to engage minorities and women in science and engineering associated with NASA space science investigations. Overall, the goal of the RBSP E/PO Program is to strengthen NASA and the nation's future workforce, attract and retain students in the STEM disciplines, and engage Americans in the RBSP mission.

## 2 Formal Education

The formal education program strives to promote careers in science, technology, engineering and mathematics (STEM), fusing a pipeline of future scientists and engineers with a science literate community. A review of literature in a National Science Board (2010) report

titled, “Science and Engineering Indicators: 2010,” reported student enrollment in certain high school courses, such as advanced mathematics, is linked to college enrollment and success. Additional studies cited found that a critical factor for successful teaching was the educator’s level of skill and knowledge in the subject matter. Another NSB (2007) report states, “No Child Left Behind mandates that all students be taught by teachers who not only are fully certified and possess at least a bachelor’s degree, but also demonstrate competence in subject knowledge and teaching.” In its 2007 policy recommendations regarding STEM education, the NSB emphasized that STEM teachers should receive adequate STEM content knowledge that is aligned with what they are expected to teach. Similarly, a report from the National Research Council of the National Academies (2007) advocated that teacher preparation and professional development programs focus on boosting teachers’ knowledge of science, how students learn the subject, and methods and technologies that aid science learning for all. To fulfill these needs, the RBSP formal education program strives to provide quality professional development opportunities and resources that are tied to national standards to support and assist educators teaching critical STEM courses that will lead to student success in these areas.

The Radiation Belt Storm Probes E/PO formal education programs (grades 5–12) is designed to engage teachers and students by using the excitement of this current NASA program to contribute to a greater understanding of science, mathematics, engineering and technology concepts—ultimately inspiring the next generation of explorers. These programs align with the National Research Council’s National Science Education Standards and focus on the key messages of the RBSP mission. RBSP formal education efforts such as creation of lesson plans and teacher training strives to contribute to the broader educational community’s confidence in their ability to find and use resources and teach about fundamental science concepts of space weather phenomena and how those processes influence Earth and people. Materials are tailored to be RBSP specific with the goal of complementing the existing NASA formal education efforts.

The formal education program focuses on the fundamental science of Van Allen Radiation Belts as well as the process of designing and building the RBSP spacecraft to operate in such an extreme environment. Key concepts focus around the strange and fascinating behavior in the radiation belts, how we are discovering the drivers behind these phenomena and the importance of gaining a better understanding of this critical region of near Earth space. Another main idea is that the discoveries made here in our “back yard,” can be applied to other places and phenomena in the universe; that in many ways this region serves as a near Earth laboratory for discovering the mysteries of not only our own Van Allen belts, but of the universe.

Additionally, our program is aligned with recommendations made by the National Research Council’s National Science Education Standards Content Standards. For example standards for grades 5–8 state that at this level, “Students begin to see connections between light, heat, sound, electricity, and magnetism. Focus is on macro view of atomicity, i.e. density. Few students can comprehend the idea of atomic and molecular particles, but it can be discussed on a macro level.” Therefore, RBSP programming for middle school students and educators is primarily aligned with content standards which address Science and Technology, Science in Personal and Social Perspectives, Science and Technology in Society, and History and Nature of Science.

Higher level physical science concepts relating to the RBSP mission such as the type, movement and density of electrically charged atomic particles and the influence of electric and magnetic waves upon them are most appropriate for high school and undergraduate programming. According to the National Science Education Standards, students in grades 9–12



**Fig. 2** Educators participating in a Sun-Earth education activity during the annual Heliophysics Educator Ambassador (HEA) workshop at the Adler Planetarium, Chicago, IL. HEA is a partnership between several Universities, the Adler Planetarium, and NASA centers. Image credit: Nancy Fiegel

“develop the ability to relate macroscopic properties of substances to microscopic structure of substances.” The Physical Science Content Standard for grades 9–12 calls for student understanding of the structure of atoms, the structure and properties of matter, motions and forces, the conservation of energy and increase in disorder, and interactions of energy and matter. Much of RBSP science content is aligned with these fundamental concepts as well as concepts found in the other content standards for grades 9–12. Although there are some connections with K-4 educational content, RBSP mission concepts most appropriately align with the needs of students and teachers of grade levels 5–12, therefore most of the formal education programming is geared toward this audience. For a chart detailing RBSP content ties to the National Education Science Standards please see Table 1.

The formal education program is designed to provide educators and students with experiences and opportunities to enhance their interest in STEM disciplines. The higher education program will provide educational programming designed to encourage opportunities for future employment for undergraduate students, including internships during the integration and test phase of missions and instruments.

The Radiation Belt Storm Probes E/PO formal education program builds on existing partnerships with professional educators and organizations. These partnerships provide nationwide coverage as well as the opportunity to reach a broader number of students and educators. E/PO partners have well-defined roles and bring their experience to various areas of the E/PO program such as design, development and dissemination of curriculum and exhibits. These partnerships also ensure implementation and evaluation of the professional development programs. Forging and maintaining high leverage partnerships is key to the success of the E/PO programs as they ensure broad nationwide dissemination of the E/PO programs. Teachers participating in a workshop that is possible due to such a partnership are shown in Fig. 2.

## 2.1 Lesson Plans and Curriculum

The E/PO team has contracted with a dedicated team from Montana State University-Bozeman (MSU) Department of Physics to develop classroom-ready learning modules exploring concepts relevant to Earth’s radiation belts, geomagnetic storms, and the dynamic solar wind interaction. Care has been taken to avoid redundancy in education materials. The curriculum design team has worked with multiple NASA education initiatives and is aware



of and attentive to the needs of the education community. The design team also works under the supervision of the RBSP E/PO team who are members of the Heliophysics Forum and the Heliophysics Educator Ambassador communities. In addition, the team regularly checks the NASA education materials website to survey Heliophysics related curricula and how they may be leveraged. Module topics may include, but are not limited to: the interaction between charged particles and a magnetic field, general magnetism concepts, the radiation belts and their effect on communication satellites, and the purpose for twin spacecraft in this mission. Modules will be web-accessible for both students and teachers, and will be aligned with

**Table 1** RBSP content alignment to the National Science Education standards

Content standard	RBSP tie to content standard
<p>Grades K-4</p> <p>B: Physical Science: Light, heat, electricity, and magnetism</p> <p>E: Science and Technology: Understanding About Science and Technology</p> <p>F: Science in Personal and Social Perspectives: Science and Technology in Local Challenges</p> <p>G: History and Nature of Science: Science as a human endeavor</p>	<p>Grades K-4</p> <p>B: Electric currents can create magnetic effects-RBSP is investigating electric and magnetic fields</p> <p>E: RBSP scientists and engineers use tools to solve problems and work in teams with many different types of people</p> <p>F: Information gained by RBSP will be used to improve space weather forecasting and design new technologies</p> <p>G: Scientists and engineers working on the RBSP mission build on the contributions of other scientists and engineers, especially James Van Allen and his team</p>
<p>Grades 5-8</p> <p>B: Physical Science: Transfer of Energy</p> <p>C: Earth and Space Science</p> <p>D: Science and Technology: Students begin to differentiate between science and technology</p> <p>E: Science in Personal and Social Perspectives: Role of technology in relation to personal and societal issues</p> <p>F: Science and Technology in Society: Societal challenges inspire questions for scientific research and social priorities often influence research priorities through availability of funding for research. Science and technology have advanced through the contributions of many different people, cultures, and times in history. Scientists and engineers work in many settings</p>	<p>Grades 5-8</p> <p>B: RBSP science addresses many concepts in this standard, including but not limited to: the sun as a major source of energy; energy is associated with heat, light, electricity, motion, sound, nuclei, and nature of chemicals; energy is transferred in many ways</p> <p>C: RBSP content can be used to expand the concepts in the Structure of Earth System section to include geospace, Sun/Earth connections fits well in Earth in the Solar System</p> <p>D: Special engineering design of the RBSP spacecraft, as well as the need for two spacecraft apply to the concepts addressed in Understandings about Science and Technology; Abilities of Technological Design</p> <p>E: Solar storms, risk analysis and how these relate to the RBSP mission can be discussed in the Natural Hazards section of this standard</p> <p>F: The Van Allen Belts were discovered years ago, but there is now a greater need to expand our understanding due to an increased societal dependence on technologies in this region. As a result there are additional resources allocated to gain greater understanding. The contributions of many individuals and teams working in a variety of settings and disciplines make this mission successful</p>

**Table 1** (Continued)

Content standard	RBSP tie to content standard
Grades 9–12	Grades 9–12
B: Physical Science: Structure of Atoms particles, waves, and radiation Motions and Forces; Conservation of Energy and Increase in Disorder; Interactions of Energy and Matter	B: RBSP is investigating the type and energies of particles in the Van Allen Radiation Belts as well as how the particles are influenced by electric and magnetic waves. RBSP science directly addresses many of the concepts in the physical science content standard
D: Earth and Space Science: Energy in the Earth System: Earth systems have internal and external sources of energy. The Sun is the major external source of energy	D: RBSP is a Living With a Star (LWS) mission. “The LWS Program provides missions to improve our understanding of how and why the Sun varies, how the Earth and Solar System respond, and how the variability and response affects humanity in Space and on Earth.”—NASA
E: Science and Technology Understandings About Science and Technology	E: Many of the principles and concepts central to end to end RBSP mission planning, design, building, testing, launching, data collection and analysis can be applied. Examples of applicable content topics include but are not limited to: system design, cost, risk, benefit, and tradeoffs
F: Science in Personal and Social Perspectives Natural and Human Induced Hazards	F: Space and ground based systems which our society depends upon are vulnerable to solar storms and changes in the radiation belts. The hazards of the radiation belts and the precautions taken to protect astronaut and airline passengers’ health during solar events may be applied here as well
G. History and Nature of Science Science As a Human Endeavor: Individuals and teams have contributed and will contribute to scientific enterprise Nature of Scientific Knowledge: Science and Culture	G: Each instrument team’s contribution is essential to the understanding of the radiation belts. Greater understanding of the Van Allen Belts will result from individual and team contributions, in the future as they have in the past Comparison of cultural explanations and scientific explanations of various Heliophysics phenomena such as the Aurora and “whistlers” may be discussed

the NRC National Science Education Standards (NRC 1996), AAAS Benchmarks (AAAS 1993), the NCTM Principles and Standards for School Mathematics (NCTM 2000), and the ITEEA Standards for Technological Literacy (ITEEA 2007). Each module will include an educator guide with a background science section, student handouts, suggested activities, cross-curricular references, adaptations for students with disabilities, and specific standards addressed. At least one module will be accompanied by an online interactive learning tool to engage learners by conveying complex and dynamic concepts in an interactive web-based environment. Another module will employ problem-based learning to challenge students to apply science, technology, and engineering concepts to real life problems.

The RBSP team is also collaborating with Dr. Sten Odenwald of SpaceMath @ NASA. Dr. Odenwald is creating standards based RBSP mathematics problems for middle school and high school level students which will be housed on the SpaceMath @ NASA website, the RBSP website, and will be distributed through educator networks.

Students in grades 5–8 will develop a greater appreciation of RBSP science and the Sun/Earth system with programming designed to align with the National Science Education Standards’ Transfer of Energy section of the Physical Science standard, as well as the con-



tent standards for Earth and Space Science and Science and Technology. Other important mission concepts, such as our reasons for studying the Van Allen Radiation Belts, how our discoveries will influence future space science studies and understanding, technological advances, as well as our modern way of life, are aligned well with Science and Technology in Society, and Science in Personal and Social Perspectives content standards.

As discussed previously, investigations of the physical properties of the radiation belts are best aligned with the 9–12 content standards although some concepts may be applied to other grade levels (Table 1). The understanding of atoms past early large scale notions typically develops after middle school (NRC 1996). The structure of atoms, structure and properties of matter, interactions of energy and matter, conservation of energy and increase in disorder fall within the required physical science content guidelines at this level. These topics provide opportunity to incorporate lessons specific to RBSP, such as the types and movement of particles within the radiation belts, energy fluxes, the influence of magnetic fields and the methodology of measuring data over space and time into the framework of the Physical Science content standard. Students further develop their understanding of RBSP mission concepts with lessons that fit within the Earth and Space Science, Science and Technology, and Science in Personal and Social Perspectives content standards.

The RBSP progression of lesson plans is created to address science standards for grades 5–12 and is aligned with NASA's Education Outcome #2: "attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers and faculty." These lesson plans and curriculum will offer exciting and educational opportunities in which teachers and their students can engage with RBSP mission science and engineering concepts as well as learn more about the human involvement and impact of the mission. Educators learning activities which align with RBSP programming and the National Science Education Standards are shown in Fig. 3.

All modules will be formally reviewed through the NASA Earth and Space Science Education Product Review (ESSEPR) process, the outcome of which includes their identification as exemplary products in the NASA Space Science Education Resource Directory (SSERD). After the modules and activities are approved through NASA's review process, they will be widely disseminated through NASA's space science education resource directory, the RBSP website, as well as through educator networks and educational partners.

## 2.2 Heliophysics Educator Ambassador Program and Teacher Workshops

RBSP has partnered with other NASA missions in the Heliophysics community (IBEX, ARTEMIS, MMS, TIMED, AIM, Cluster and RHESSI) for the Heliophysics Educator Ambassador (HEA) Program. The RBSP E/PO team will continue to sponsor five educators per year to participate in the HEA program through the life of the program as they have in the years 2009–2011. The RBSP team will also continue to fully participate in the annual HEA educator workshop, and participate as needed in the planning sessions, follow up meetings, and evaluative discussions. During the 2009 and 2010 workshops information and classroom resources were presented to the educator group as a whole with a question and answer session following the presentation. During the July 2011 HEA workshop, the story of the RBSP mission was presented to 28 educators broken up into 3 smaller groups to allow for in depth discussions. RBSP science, engineering, and classroom resources relating to the mission were presented during each presentation, keeping in mind the educational needs of the participants. The HEA workshop format is aligned with the numerous studies that have found that the most effective professional development opportunities: "Focus on subject content, provide an intensive and sustained approach, are presented in a format of



**Fig. 3** Educators learning activities which align with RBSP programming and the National Science Education Standards during the National Science Teachers Association Regional Conference in Baltimore, MD. Teachers heard about RBSP mission objectives, science, and engineering then participated in activities that align with the mission objectives and the science standards they need to cover in their classrooms. Image credit: JHU/APL

teacher network, study group, mentoring, and coaching as opposed to a traditional workshop or conference, is connected or related to teachers' daily work, emphasizes a team approach and collaboration, and provides opportunities for active learning" (NSB 2007).

The workshop is aligned with the National Science Education Standards, especially Professional Development Standards A and B. Standard A, subcategory two states, learning experiences for teachers must "address issues, events, problems, or topics significant in science and of interest to the participants." A focus of the oral presentation is the explanation of how the events in the Van Allen Radiation Belts directly affect the modern way of life of the participants and their students. Teachers are given resources and direction to locate additional resources, meeting the third subcategory of Standard A: "Introduce teachers to scientific literature, media, and technological resources that expanded their science knowledge and their ability to access further knowledge." A primary goal of participation in the workshop as a whole is to meet Professional Development Standard B, subcategory three: "Address teachers' needs as learners and build on their current knowledge of science content, teaching, and learning."

The RBSP E/PO team provides access to current science and engineering concepts as it relates to RBSP through dissemination of materials and classroom activities and presentation of information. Additionally, the RBSP E/PO team participated in several mentoring sessions throughout the HEA workshops and will continue to participate fully at future workshops. During the mentoring segments of the workshop, educators have the opportunity to interact with the team members to ask questions of "mission experts" as they create an outline of the workshops they will be presenting to other educators. Through this experience the fourth subcategory of Professional Development Standard D is addressed: "Quality

pre-service and in-service programs are characterized by collaboration among the people involved in programs, including teachers, teacher educators, teacher unions, scientists, members of professional and scientific organizations, parents, and business people, with a clear respect for the perspectives and expertise of each.”

The Heliophysics Educator Ambassadors program is aligned to NASA’s Education Outcome #2: “attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers and faculty.” Professional development experiences for the nation’s teachers will support the ultimate goal of helping them attract, retain, engage, and educate students in STEM disciplines, and creating a more science and technology literate workforce. Because this program not only reaches the teachers that participate directly in HEA workshops, but also has the ripple effect of educator to peer dissemination around the country, it represents a unique and particularly significant opportunity to impact a large audience. *The Heliophysics Educator Ambassadors Program Alaska 2009 and Chicago 2010 Final Evaluation Report* shows the 58 HEAs trained in these two workshops went on to conduct 141 workshops with 2102 participants, known as Tier 2 educators, and reached 8095 students. The Tier 2 educators trained by HEAs then reached over 296,000 students and nearly 19,000 additional educators (Cornerstone Evaluation Associates LLC 2012). As future HEA workshops are planned and executed, the logistics and the format of the programming may change, but the RBSP E/PO team’s level of participation and the focus on the needs of the teacher participants during this important program will remain constant. Further information about the HEA program can be found on the HEA website <http://cse.ssl.berkeley.edu/HEA/>. An image taken during the 2010 HEA educator workshop is shown in Fig. 4.

### 2.3 Pre-launch Teacher Workshop

The Radiation Belt Storm Probes E/PO team conducted a pre-launch teacher workshop at Johns Hopkins University Applied Physics Laboratory. The two and a half day workshop gave 31 middle school, high school, undergraduate and informal educators from 21 states an opportunity to be trained on the mission by key mission team members, addressing the fourth component of the Professional Development Standard D: “Quality pre-service and in-service programs are characterized by collaboration among the people involved in programs, including teachers, teacher educators, teacher unions, scientists, members of professional and scientific organizations, parents, and business people, with a clear respect for the perspectives and expertise of each.” It also aligns with Professional Development Standard C: “Professional development activities must provide opportunities to know and have access to existing research and experiential knowledge.”

The workshop was truly a collaborative effort. Representatives of each of the five instrument suites gave tutorials and a hands-on demonstration of activities that could be adapted for the formal or informal classrooms. Twenty-two RBSP science, engineering, mission operations, and launch services team members participated. The planning and implementation of this workshop was carried out by the APL RBSP E/PO team.

The first day of the workshop offered an overview of the mission science and engineering. The focus of day two was a more in depth look at the mission instrument science. The third day was open for the educators to present their ideas and work toward creating new RBSP education materials. Participants also saw the cleanrooms where RBSP was built, toured integration and test facilities where RBSP put through the rigors of the space environment, and visited the APL mission operations center where RBSP will be controlled. Each day was comprised of a mixture of lectures, question and answer sessions, hands-on activities,



**Fig. 4** Heliophysics Educator Ambassadors work together to map out magnetic field lines as part of an activity related to RBSP. Throughout the weeklong workshop, teachers hear from experts of various NASA Heliophysics missions and participate in mission related hands on activities, Adler Planetarium, Chicago, IL. Image credit: Nancy Fiegel

and time for educators to interact with one another. This time allowed them to discuss the content learned and how they would modify for their audiences and integrate it into their individual educational settings. Many mission representatives remained to interact with the teachers informally and be on hand to answer questions. Summative reports have not yet been compiled, however preliminary formative daily feedback indicate the teachers found the interaction with mission experts and the time to work with peer educators to be valuable aspects of the workshop.

The goal of this workshop was for educators from a wide range of backgrounds to gain an appreciation for the importance of the RBSP mission, comfort with the materials and mission concepts, and confidence in their ability to modify the materials to bring the mission concepts to their own students. The format was designed to give educators the opportunity to be students, to learn mission concepts through lecture, question and answer, hands on activities, and peer to peer education. The workshop addressed the third component of Professional Development Standard B of the National Standards: “Learning experiences for the teachers of science must address teachers’ needs as learners and build on their current knowledge of science content, teaching, and learning.” This opportunity was open to educators nationwide and provided a \$750 stipend for travel expenses for each teacher. Backgrounds and audiences were diverse. There were eight middle school teachers, twelve high school, three undergraduate, and eight informal educators that participated. Photos taken at the Pre-Launch workshop are shown in Figs. 5a–c.





(a)



(b)



(c)

**Fig. 5** Photos taken at the RBSP pre-launch teacher workshop held at Johns Hopkins University Applied Physics Laboratory, July 31–August 2, 2012. Thirty-one middle school, high school, undergraduate and informal educators from twenty-one states participated. Image credits: (a) Frank Morgan; (b, c) Dawn Turney

Like the HEA program for teachers, the launch site teacher workshop is aligned to NASA's Education Outcome #2: "attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers and faculty." The unique opportunity of providing a professional development workshop at the location where RBSP was built, tested and will be operated, while involving RBSP mission scientists and engineers, was an important aspect of generating excitement for the RBSP mission among middle and high school teachers.

## 2.4 Pre-service Teachers Heliophysics Workshop

The RBSP E/PO team will partner with historically black colleges and universities (HBCUs) in the Maryland and DC areas to recruit participants for a Pre-Service Teachers Heliophysics Workshop (PTHW). Faculty from the Education Departments for Howard University, Morgan State University, and the University of Maryland, Eastern Shore, were approached to assist the RBSP E/PO team in recruiting students in their programs for the workshop. These workshops will provide professional development opportunities to pre-service teachers close to finishing their education degrees at HBCUs in an effort to target participants that are underrepresented in STEM fields. Conversations with faculty from the HBCUs involved have led to the idea that the students will participate in a 1-day workshop that will take place at APL, followed by campus visits and/or web-seminars by the RBSP scientists and engineers. The content will include the RBSP key messages, fundamental science and engineering highlights, as well as a general overview of the Sun-Earth relationship. Techniques for incorporating this content into current National Science Education Standards will also be addressed so that the teachers can easily incorporate workshop themes into their future classroom curriculum. Pre-service teachers that are pursuing their education degrees in STEM disciplines will be given priority, but pre-service teachers that will be teaching non-STEM disciplines will also be considered if room is available.

The goal of the PTHW is to enhance awareness and understanding of RBSP mission science and engineering among historically underrepresented groups in the sciences. Additionally, engaging teachers early in their education career may give them confidence in teaching these topics as they begin to build a repertoire of lessons they are comfortable integrating into future classroom curriculum. Workshop facilitators will also emphasize to the participants that continuing to look to NASA for future teacher professional development opportunities and resources will benefit their classroom experience, and a list of these types of opportunities and resources will be shared.

An added benefit from the partnership with the faculty at Howard University (HU) is that involvement of HU students with this workshop will help support research for a NSF grant awarded to the HU Education Department titled, "What Works in Producing African American Science and Math Teachers at HBCUs." Dr. Kimberly Freeman, the PI for this grant and an RBSP E/PO partner, expects the investigation to yield data that can be used to strengthen science and math teacher preparation programs at HBCU's; improve recruitment of prospective science and math teachers; and inform higher education policy. Dr. Freeman has expressed interest in using the experiences and outcomes of the PTHW to add to the body of data for this critical study. Better preparation of minorities to teach STEM disciplines is critical in increasing the effectiveness of the K-12 education system to prepare minority youth in the STEM disciplines. According to a AAAS article published in 2008 titled, "African Americans Studying STEM: Parsing the Numbers" (Sasso 2008), it is not a lack of interest in science that is holding minority students back from STEM careers, rather that it is a cumulative effect of not attaining the prerequisites in their K-12 education needed to



continue onto a successful STEM career. Compounding this effect is that minority students are missing STEM teachers and role models with whom they can identify with. In essence, the presence of African American STEM teachers and role models needs to increase in order to overcome these challenges.

This program, like the other teacher workshops planned and facilitated by the RBSP E/PO team is aligned with the National Science Education Professional Development Standards. Specifically, the workshop will “address issues, events, problems, or topics significant in science and of interest to participants, introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge, build on the teacher’s current science understanding, ability, and attitudes, and encourage and support teachers in efforts to collaborate.” These aspects of Professional Development Standard A will be of particular significance as the pre-service teachers begin their careers and have a heightened need for support and resources. Throughout the workshop, the facilitators will be mindful to “address teachers’ needs as learners and build on their current knowledge of science content, teaching and learning,” as well as “provide an opportunity to have access to existing research,” as recommended in Professional Development Standards B and C. In addition, the E/PO team will provide a quality pre-service program as characterized by meeting many of the components cited in Professional Development Standard D, “conducting the program in a way that recognizes the developmental nature of teacher professional growth as well as the needs of teachers who have varying degrees of expertise, professional expertise, and proficiency.” This characterization will be evident to an even greater degree if teachers from disciplines outside the STEM fields are participants. As an integral part of the workshop, teachers will interact and “collaborate with mission experts, other teachers, teacher educators, and members of professional and scientific organizations.” The program will be assessed by Cornerstone Evaluation ensuring that the “assessment captures the perspectives of all involved, uses a variety of strategies, focuses on the process and effects of the program and feeds directly into the program improvement and evaluation” as recommended by the National Science Standards.

This workshop is unique because it simultaneously is aligned to NASA’s Education Outcome #2: “attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers and faculty,” as well as NASA’s Education Outcome #3: “Contribute to the development of the STEM workforce,” where the STEM educators are a significant part of the future STEM workforce.

## 2.5 Space Academy

The APL Space Department E/PO office created the Space Academy series where students go behind the scenes of current space missions and are introduced to scientists and engineers working on these projects. These educational events are sponsored by Johns Hopkins Applied Physics Laboratory (APL) and Discovery Education. Radiation Belt Storm Probes is a regular topic of these programs.

Space Academy gives middle school students a close-up look at NASA’s missions such as the Radiation Belt Storm Probes mission. They are designed to engage, inspire, and influence attitudes about space science and STEM careers. They also provide an opportunity to engage and attract underserved populations and emphasize that space science is for everyone. Space Academy includes a student press conference with mission experts as panelists and students as “reporters.” The panelists represent varying backgrounds, careers, and roles on the mission. For example, panelists may include engineers, scientists, the Mission Operations Manager, Project Manager or other integral roles on the mission. Speakers take



**Fig. 6** Space Academy allows Maryland school students to enjoy a full day of activities including hearing from RBSP mission experts, participation in a student press conference modeled after a NASA press conference, science demonstrations and activities, and a behind the scenes tour of spacecraft testing laboratories. Image Credit: JHU/APL

turns describing different aspects of the mission and their role on the project, and then students have an opportunity to interview them as if they were part of an official NASA press conference. The event is moderated by an APL public relations representative.

After the press conference, students learn why spacecraft engineers wear white outfits called “cleanroom suits” during spacecraft integration and testing, participate in a lively science demonstration as shown in Fig. 6, and dine with Radiation Belt Storm Probes’ scientists and engineers. Lunch with the team gives students a chance to continue conversations, ask questions they may not have had time to ask during the press conference, and gives mission experts an opportunity to change attitudes about what a career in space science may be like. After lunch students put on specially-designed souvenir cleanroom suits and tour APL’s space facilities. Spacecraft and instrument team members lead student groups through a series of “exploration stations” that may include a mission operations center used to control the spacecraft; a satellite communications facility used to communicate with the spacecraft; the thermal and vibration laboratories used to test spacecraft; view spacecraft and instruments being assembled in APL’s clean rooms, and participate in a variety of mission-related hands-on science demonstrations. In preparation for their visit, students study the mission and space-related careers through a series of classroom activities and videos developed by APL and Discovery Education. They also engage in post-visit activities about the mission including their experiences during Space Academy. Schools from Baltimore City and seven

diverse Maryland counties have attended RBSP Space Academy events in the past. The E/PO office plans to feature RBSP at Space Academy once per year until 2015.

Activities throughout the day develop student understanding about science and technology and address the fundamental concepts that fall under the National Science Education Content Standards: Science and Technology; Understandings about Science and Technology. Topics are also aligned with concepts which fall under the Content Standard: Science in Personal and Social Perspectives, particularly concepts in Natural Hazards, Risks and Benefits, and Science and Technology in Society. Students are immersed in a hands-on experience designed to facilitate understanding of the concepts outlined in the Content Standard: History and Nature of Science. Throughout the day students interact with people of diverse backgrounds and interests while hearing about the specific ways various individuals and teams of people, past and present contribute to the science and technology of the mission, addressing the concepts which fall under the headings of: Science as a Human Endeavor, Nature of Science, and History of Science.

Space Academy is aligned to NASA's Education Outcome #2: "attract and retain students in STEM disciplines through a progression of educational opportunities for students, teachers and faculty." Having students come to the Applied Physics Laboratory and engage with scientists and engineers outside the classroom is an exclusive opportunity and previous Space Academies have been successful in getting students excited about mission science and engineering as well as careers in the space industry. Likewise, exposing students to a diverse group of scientists and engineers may help to alleviate some common stereotypes about these types of careers. In Chap. 15 of the Project 2016: Benchmarks for Science Literacy (AAAS 1993), many stereotypes of scientists are listed, including that they are perceived by students to be bearded, balding, working alone in the laboratory, isolated and lonely. When students engage with the scientists and engineers at APL, they see first-hand that this is absolutely not the case and that successful science and engineering requires a diverse team with multi-disciplinary background. The pre-visit classroom activities are also aligned to National Science Education Standards, so the material is appropriate for use in the classroom. More information can be found on the Space Academy website: <http://www.spaceacademy.jhuapl.edu/>.

## 2.6 APL/NASA Undergraduate Internships

The APL Space Department E/PO office partners with NASA in support of the NASA/APL internship program to provide meaningful summer positions in the Space Department. Each summer, up to 20 competitively selected undergraduate students from around the country intern at APL for a 10-week hands-on educational research experience. Students from a wide variety of backgrounds are recruited, in the tradition of encouraging multi-disciplinary student collaborations. Throughout the summer, the E/PO office provides tours and mission-related educational "brown-bag" lunchtime talks on various NASA missions. A special end-of-summer program in which interns present their summer projects and internship experiences to peers, project supervisors, and upper management at APL, affords them an opportunity to experience yet another aspect of working in a STEM career, as well as providing additional exposure to the APL community. The RBSP E/PO office has a continuing commitment to support internships dedicated to training undergraduate students in RBSP mission science and engineering. Several former NASA/APL interns have recently become full-time employees in the APL Space Department; a few specifically came back to resume their work on RBSP. Likewise, many NASA/APL interns go on to work at NASA Centers.

Students are recruited on a national scale. In order to engage the greatest talent from across the nation, the program is advertised through multiple channels with the help of critical partners. Announcements are sent out to the NASA Academy alumni as well as AIAA Mid-Atlantic members. In addition, Space Grant Consortiums partner with APL to advertise at their universities across the country. The link to the NASA/APL Internship Program is [www.aplapp.com](http://www.aplapp.com).

Interns have worked on the RBSP mission under the direction of Space Department scientists and engineers at APL, 2007 to present. 2011: 3 NASA/APL interns and 5 interns from other APL internship programs; 2010: 4 NASA/APL interns; 2009: 4 NASA/APL interns; 2008: 4 NASA/APL interns; 2007: 3 NASA/APL interns and 3 interns from the Minority University-Space Interdisciplinary Network (MU-SPIN) internship program.

Partnerships with NASA Space Grant Consortiums from around the country have supported the funding obligations of this program. Instrument teams are invited to apply for E/PO funds for their own internship opportunities or volunteer applicants from their institutions and universities.

The need for undergraduate research and internship opportunities has been well-documented. More recently, in a 2011 article published in the *Journal of Higher Education* titled, “Cross-Discipline Perceptions of the Undergraduate Research Experience” (Craney et al. 2011), the undergraduates who participated in the study stated that these types of research opportunities address their needs for research specific skills and clarification/confirmation of career paths. Additionally, female researchers were more likely than the male researchers to report that these types of research opportunities gave them prestige during college and would allow them to develop their communication and presentation skills.

The NASA/APL Internship Program is aligned to NASA’s Education Outcome # 1: “contribute to the development of the STEM workforce in disciplines needed to achieve NASA’s strategic goals, through a portfolio of investments.” The program provides practical work experience and an introduction to space science and engineering. Students spend the summer working with APL scientists and engineers, conducting research, developing leadership skills, and growing professionally. Finally, the high percentage of interns who commit to a career in the STEM workforce supports NASA’s goals.

### 3 Informal Education

The NSB (2004) suggests that the American public expresses strong support for science and technology but is not very well informed about these subjects. The attendance at science centers and museums across the country shows the public is interested in science, although they may not be following science studies in the news. For this reason the RBSP public outreach program creates opportunities to tap into this interest, reaching out to the public and increasing their awareness of RBSP mission science, such as the event shown in Fig. 7. A wide ranging informal education effort is designed to increase public interest and understanding of science, technology, engineering and mathematics activities—using the excitement of the mission to capture their attention and imaginations. This effort includes partnering with informal educators, building their skills, and contributing to the collection of informal education resources for Heliophysics. Many informal education centers, such as science centers and museums, have a wide variety of existing programs that can be leveraged for new RBSP content. These programs also compliment the RBSP mission and instrument exhibits that will be permanently housed at the partner museum and science centers.



**Fig. 7** A Maryland boy scout troop has a special and rare opportunity to go behind the scenes to view the Radiation Belt Storm Probes being built in the clean rooms while learning about engineering for an extreme environment from RBSP engineers. Image Credit: Dawn Turney

The APL E/PO office has built strong partnerships with museums and science centers across the country. The programs provide a wide range of services from full exhibits with spacecraft models and artwork for guest speakers and lectures to the development of planetarium shows. RBSP E/PO partners with these informal educators to inspire and engage a broad audience with RBSP mission science and engineering, while at the same time promoting Heliophysics and the Sun-Earth relationship information. All Informal Education programs described align with NASA's Education Outcome #3: "build strategic partnerships and linkages between STEM formal and informal education providers that promote STEM literacy and awareness of NASA missions."

### 3.1 Maryland Science Center

The Maryland Science Center (MSC) is conveniently located in Baltimore's Inner Harbor, a tourist attraction for visitors from around the country, as well as a field trip destination for school groups. RBSP E/PO partners with MSC utilizing their SpaceLink exhibit, which is part media center, part discovery room, and part newsroom focusing on the "latest and greatest" in space science and aerospace technology. RBSP scientists and engineers support these programming efforts as well as special live events to highlight mission milestones and space-related anniversaries. This allows the guest scientists and engineers to interact directly with the public at MSC. Another opportunity for direct scientist-to-public engagement is through a scientist lecture series sponsored by MSC that includes five to six lectures per year, and an RBSP scientist will be one of these lecturers. These public engagement opportunities





**Fig. 8** Partnership with the Maryland Science Center and other science museums and visitor centers allow opportunities for quality public programming and outreach where scientists and engineers have opportunities to share their excitement and knowledge with the public. Image Credit: Maryland Science Center

for RBSP scientists and engineers provide a venue in which they can put into practice the training they have received for public outreach (see Sect. 4.1).

A partnership with MSC also allows for training of other informal educators. MSC is a member of the International Planetarium Society (IPS) and will present RBSP content at IPS conferences and meetings in order to engage other informal educators with RBSP mission science and engineering. The RBSP E/PO team will be involved in creating presentations and posters alongside staff at MSC, for dissemination to other museums, science centers and planetariums. MSC will tailor the content to be fit for an informal education audience, and the RBSP E/PO team will provide scientific guidance and visualizations.

A strategic partnership with MSC engages more Americans with RBSP mission science and supports their existing efforts in offering local and regional NASA-themed educational activities and exhibits, as well as training for other informal educators. The diversity of the Baltimore area also ensures that underrepresented groups in the sciences will have direct access to RBSP scientists, engineers and content. Sixty-eight percent of Baltimore City residents are African American, American Indian, Asian and Hispanic (Source: 2010 U.S. Census, State and County Quick Facts) and Baltimore City schools, many of which are underserved Title I Schools, frequently visit MSC for school field trips (Fig. 8).

### 3.2 Partnerships with NASA Visitor Centers—KSC and GSFC

RBSP launched from Kennedy Space Center (KSC) and the E/PO program partnered with NASA's KSC Visitor Center to take advantage of the excitement naturally surrounding the launch of a spacecraft. Exhibits included, a large mission booth where visitors participated in multiple hands-on RBSP related activities and received material handouts, a model of



one of the RBSP spacecraft, and an interactive kiosk, and an exhibit along the KSC bus tour route which focused on the RBSP launch vehicle. Other launch events included the Pre-Launch Teachers Workshop (see Sect. 2.3) and visits to Brevard County elementary, middle and high schools by RBSP science team members. Contacts with local school officials were obtained through the partnership with the KSC Education Office. The number of visitors engaged during the KSC and NASA visitor center efforts were recorded and categorized to include coinciding formal education activities.

Formal Education—approximately 2,560 students and teachers reached

- Pre-launch Educator Workshop—31 educators from 21 States
- Distance Learning Network (DLN)—60 students & 2 teachers
- High schools—575 students & 15 teachers
- Middle schools—250 students & 12 teachers
- Elementary schools—500 students & 11 teachers
- INSPIRE Un-Conference at KSC—70 students & parents
- Educator Resource Center at KSC—approximately 1,000 educators

Informal Education—over 16,000 during launch week

- Four RBSP Exhibits throughout KSC Visitors Complex
- Main RBSP Exhibit in IMAX Theater with 5 hands-on activity stations
- Direct interactions and materials passed out at IMAX Exhibit—approx. 4,000
- RBSP Exhibit and video at LC 39 Tour Stop
- Interactive kiosk in Exploration Space
- Twelve Astronaut Encounter Auditorium Briefings—approximately 100 attendees
- Museum Alliance Pre-launch Training—25 informal educators
- Public Lecture at Brevard County Planetarium
- Two Guest Briefings at KSC

An RBSP mission science and engineering exhibit will be coordinated with Goddard Space Flight Center (GSFC). This exhibit will include models of the RBSP spacecraft, videos and visualizations, fact sheets and tactile models that will reinforce the understanding of Heliophysics and the Earth-Sun relationship. Exhibits at both the KSC and GSFC Visitor Centers will highlight the RBSP key messages using both visual and audio resources that will engage and inspire a broad and diverse audience. Likewise, a strategic partnership with both the KSC and GSFC Visitor Centers will support their existing efforts in providing informal education resources and tools that use NASA's unique content to connect NASA's missions to self-directed learners, and to attract individuals to STEM careers.

### 3.3 Museum Alliance

The Museum Alliance is a partnership between NASA's Solar System Exploration Program and museums, science centers, and planetariums across the country bringing the adventure of space exploration to students, educators, and the public. It is intended to bring real-time data and current science and technology to museum visitors through visualizations and professional development of the museums' staff.

The RBSP E/PO program partners with the Museum Alliance, managed by the Jet Propulsion Laboratory (JPL). Members of the Museum Alliance will be trained on the science and engineering of the RBSP mission by key project personnel and will be equipped with mission materials to conduct their own regional RBSP events and workshops at their

home museums, science centers, and planetariums. The strategic partnership with the Museum Alliance network embeds NASA expertise and content among members of the Museum Alliance who create or offer local, regional or national NASA-themed educational activities and exhibits. Additionally, the RBSP E/PO office will also support opportunities and activities that may come about through these partnerships.

### 3.4 Launch Events

RBSP launched window opens in August of 2012. The instrument sites and the entire E/PO office was involved with launch efforts on behalf of the mission. All of the RBSP E/PO partners, RBSP Educator Ambassadors, and instrument teams were invited and encouraged to host and conduct regional outreach at their home institutions during launch or participate in launch efforts held at Kennedy Space Flight center and surrounding counties. The Museum Alliance members, Solar System Ambassadors, HEAs, and Solar System Educators were also encouraged to conduct their own regional events and activities.

## 4 Public Outreach

The RBSP E/PO program engages the public in shaping and sharing the experience of space exploration through its Public Outreach programs. These programs strive to allow the public access to real-time data, milestone events, and general mission and instrument information in easily accessible formats such as videos and animations, a mission website, printed materials, and at times direct scientist/engineer interaction. There will also be an E/PO training workshop for RBSP scientists, engineers and project management so that the public may have greater access to the expertise of the RBSP mission. The goal is to contribute to the overall advancement of the nation's scientific and technical awareness of the RBSP mission.

Like Education Portfolio Strategic Framework Outcome #3—Informal Education—the Public Outreach programs will inspire and engage the public with STEM disciplines as they are applied to RBSP mission science.

### 4.1 Education and Public Outreach Training for Scientists, Engineers and Project Management

Educational research and first-hand experience demonstrates that involving more scientists and engineers in E/PO activities increases audience interest and learning about scientific topics (Buxner et al. 2012; Morrow and Dusenbery 2004; Ecklund et al. 2012; Morrow 2003; Young 2007). Many opportunities exist within the RBSP E/PO plan for scientists and engineers to get involved with education and public outreach activities. More direct interaction between audiences in the E/PO field (K-12 students, educators, public, etc.) with scientists and engineers is beneficial for both parties. The audiences are excited to interact with real-life scientists and engineers and are exposed to subject expertise, while the scientists and engineers gain first-hand experience in building relationships with the public and sharing their knowledge as seen in Fig. 9. In a document titled, “Workshops for Scientists and Engineers on Education and Public Outreach,” by C.A. Morrow and P.B. Dusenbery, the authors state that space scientists and engineers offer much that is needed to contribute to education and public outreach. This includes: (1) respect and influence in their communities; (2) expertise in science and the scientific process; (3) exciting connections to real world exploration and discovery; (4) education access to data and facilities,



(a)



(b)

**Fig. 9** Scientist Dan Smith (a) and engineer Elliot Rodberg (b) share their knowledge and enthusiasm about the RBSP mission with students and the public. Team members support is integral to the success of the E/PO program. Image Credit: (a) Dawn Turney; (b) Ed Whitman, JHU/APL

and (5) role modeling for students and teachers. For these reasons, the RBSP E/PO Public Outreach program will include a workshop focusing on E/PO training for RBSP mission scientists, engineers and project management. Heliophysics, and the science and engineering behind the RBSP mission, are complex topics, but topics that the public can understand and relate to their everyday lives. In order to make these topics more accessible to education and public outreach audiences, subject matter experts are given the opportunity to learn how to communicate topics effectively using language that is appropriate at various levels of science literacy (Morrow and Dusenbery 2004; Ecklund et al. 2012; Young 2007).

The workshop will be held in conjunction with the RBSP Science Working Group meeting in order to ensure maximum attendance by mission scientists and engineers. The workshop include topics such as best practices for communicating science to a broad audience (Morrow and Dusenbery 2004 and Young 2007) and an overview of National Science Education Standards as they relate to RBSP, Heliophysics, and the Sun-Earth system for presenting these topics in the classroom. Additionally, an overview and discussion on current astronomical and space science misconceptions will be included (Sadler et al. 2010). At the end of the workshop the E/PO team recruits RBSP mission scientists and engineers for participation in upcoming E/PO opportunities (for example interviews for mission videos, speakers for Space Academy, teacher workshops, etc.). The scientists and engineers are encouraged to participate in RBSP E/PO Formal Education, Informal Education, and Public Outreach programs either as an advocate, a resource or a partner, as described in Appendix C of the NASA Explanatory Guide to NASA Science Mission Directorate Education and Public Outreach Evaluation Factors (2010).

This workshop aims to inspire and prepare RBSP mission scientists and engineers to get more involved with education and public outreach opportunities, while also training them in effective techniques for conducting education and public outreach. Sharing their enthusiasm for mission science with students, educators, families and the general public will ultimately increase Americans' science and technology literacy.

#### 4.2 “Girl Power” Event at APL

The Girl Power event at APL is an annual public outreach activity that invites middle and high school girls to be inspired by the science, mathematics, engineering and technology activities at APL. Among the many booths displaying research in high impact STEM fields, RBSP is highlighted. RBSP mission scientists and engineers staff the booth and interact with the girls, even encouraging them to stay in contact after the event. The interactive activities at the RBSP booth have included dressing up in cleanroom suits as seen in Fig. 10, and a hands-on magnetic field line activity that demonstrates the shape of the Earth's magnetic field. Activities that highlight other APL Solar System exploration missions are demonstrated alongside the RBSP mission activities to emphasize the multi-disciplinary nature of space science. Throughout the event girls and their families interact with scientists and engineers of diverse backgrounds and interests while hearing about the specific ways various individuals and teams of people, past and present contribute to the science and technology of the mission. In this way, the event is aligned with the concepts of the National Science Education Content Standard: Science as a Human Endeavor, Nature of Science, and History of Science. Each year, the number of participants has grown. Last year, over 500 middle and high school girls and their families participated in Girl Power, engaging with 155 mostly female scientists and engineers. RBSP will continue to support this outreach activity throughout the mission's lifetime. The need to target girls for STEM education and careers has been



**Fig. 10** Three future engineers show off their new fashion sense after spending time learning about building RBSP from APL's Safety and Quality Assurance Group Supervisor, Emily Broderick, a volunteer at the Girl Power event. Image Credit: Connie Finney

well-documented. A literature review in the *Journal of Women and Minorities in Science and Engineering* titled, "Collaboration as a Means to Building Capacity: Results and Future Directions of the National Girls Collaborative Project" (Marra et al. 2008), noted that factors such as perceptions of careers, confidence, role models, and career advice have been highlighted in the literature as contributing to the lack of females in STEM. The high number of RBSP female scientists and engineers who participate in Girl Power illustrates to the female students that careers in science and engineering are for everyone. Additionally, contact information for each female scientist and engineer is given to each student participating in Girl Power. The participants are encouraged to keep in touch with the role models they have met that day.

#### 4.3 RBSP Video Series/Visualizations/Animations

Easy access to high quality videos, visualizations and animations guarantees that the public will be exposed to exciting science and engineering topics related to the RBSP mission. These products are for educational and public outreach use covering the development of the RBSP mission from instrument delivery through launch and showcasing science returns. Segments of the program also appear on the web. APL creates all of the mission animations and visualizations in both HD and standard definitions for multi-use purposes. They are integrated into produced video products, incorporated into Magic Planet programming, which is an interactive digital video globe and placed on the mission web site. There were



approximately 52,750 views of video and animation accessed from the RBSP website between January and September, 2012 (JHU/APL). The video series and animations are 508 compliant and are made available to media outlets as well as museums and science centers ensuring maximum exposure to the general public.

The pre-launch video series will include an RBSP movie trailer (currently posted on the RBSP website), a short mission video of about three minutes, and a longer follow-up video of about three to five minutes which will include interviews from mission scientists and engineers. Post-launch, three to five new animations will be created per year that highlight new discoveries in radiation belt science and the interaction of the RBSP spacecraft with the radiation belts.

#### 4.4 Mission Web Site

According to NSB (2004), the Internet has had a major impact on how the public gets information about science and technology, and is the preferred source when people are seeking information about specific scientific issues. For this reason, the RBSP website is designed to engage and inspire excitement about the mission and to help people understand its significance through formal and informal education resources. General awareness includes mission updates and interest pieces. Instrument team news as well as spacecraft news and highlights are showcased here. There were approximately 2,460,500 hits and 169,600 pages visited on the RBSP website between January and September 2012. About 28 % of the total number of hits and 25 % of pages visited were accessed by United States educational institutions (JHU/APL).

The RBSP mission website is <http://rbsp.jhuapl.edu>. It features the latest news about the mission and a monthly spacecraft team perspective column. Features include sections on the following: overview; science; mission, spacecraft; education; news center; gallery and links, among other special elements (Fig. 11). The main RBSP mission website will also include links to RBSP instrument team websites. Leveraging off our strong public affairs partnership, the APL Public Affairs office oversees daily updates for the website, focusing on news and other releases. The E/PO office maintains the website education pages and will coordinate with Public Affairs office as necessary when new items become available. The E/PO team is responsible for the education webpage.

### 5 Product and Program Evaluation

Both a systematic product evaluation/review and a comprehensive program evaluation plan are critical elements for ensuring that the RBSP E/PO effort is built on a sound foundation and is successful in achieving its objectives. The purpose of the product evaluation is to ensure the pedagogical and scientific merit of lesson plans, curriculum and other materials developed as part of the RBSP E/PO project. Program evaluation involves a multi-method approach for gathering both quantitative and qualitative information to provide the RBSP E/PO team with continual feedback for making data-driven decisions and improvements and to determine the effectiveness and impact of RBSP's E/PO effort.

#### 5.1 Product Evaluation

To ensure the pedagogical soundness and scientific accuracy of products and materials developed under the umbrella of the RBSP E/PO project, products undergo expert reviews



The screenshot displays the 'Radiation Belt Storm Probes Mission' website. The header includes the mission name and tagline 'Exploring the Extremes of Space Weather', along with an image of the spacecraft. A navigation bar contains links: HOME, MISSION, SPACECRAFT, SCIENCE, DATA, NEWS CENTER, EDUCATION, and GALLERY. On the left, a sidebar lists various sections: MISSION OVERVIEW, MISSION TIMELINE, THE TEAM, CONVERSATION WITH THE TEAM (highlighted), MISSION OVERVIEW AND SUN EARTH CONNECTIONS, ROCK AND ROLL – ACOUSTIC TEST, MEET THE INSTRUMENT PRINCIPAL INVESTIGATORS, and PROBING QUESTIONS. The main content area is titled 'Mission Overview and Sun Earth Connections' and features two interactive sections. Section 1, 'Choose a question:', lists 20 questions about the radiation belts, mission goals, and spacecraft. Section 2, 'Select a team member:', shows a video of Nicky Fox, RBSP Deputy Project Scientist, with a 'View Transcript' button and a 0:05 timer. A small graphic of the radiation belts is also visible.

**Fig. 11** The Conversation with the Team portion of the website features scientists and engineers answering questions of their choice from a menu of space science and mission questions. This section is especially useful for those who are just discovering the RBSP mission and/or the science of Heliophysics, as well as for those who want to enhance their knowledge. Image Credit: JHU/APL

(both for ‘best practices’ pedagogy and scientific content), field testing, and the NASA education product review. The majority of lesson plans, activities and curriculum that will be used throughout RBSP’s formal education programs will be produced by Montana State University (MSU). MSU will carry out expert pedagogical reviews and field testing on the materials they develop. Reviews of scientific accuracy will be conducted by a team of APL scientists, engineers and program managers (N. Fox, D. Smith, R. Fitzgerald, A. Santo, B. Mauk, J. Stratton) on all lesson plans and curriculum designed by MSU as well as all other products and activities developed as part of the RBSP E/PO project.

Additionally, RBSP E/PO partners coordinate with the APL RBSP E/PO team prior to the public release of any materials, products, curricula or deliverables (either electronic or print) produced under the mission’s E/PO effort. E/PO partners and team members field test the materials they develop on their suggested target audiences. Feedback from this testing is integrated into the final products.

## 5.2 Program Evaluation

An external evaluator is charged with designing and carrying out an evaluation plan in order to determine the effectiveness of RBSP E/PO in meeting its objectives/goals and the overall impact of the RBSP E/PO effort. Cornerstone Evaluation Associates LLC is collaboratively partnering with the RBSP team in tailoring evaluation activities to fit the needs of each of RBSP’s programs. Cornerstone takes the primary responsibility for (1) designing all data

collection instruments, (2) facilitating the collection of all data, (3) managing, analyzing and interpreting all data and (4) providing ‘as needed’ feedback for informed decision-making and a final summary report focused on RBSP’s outcomes. This evaluation also assesses the impact of RBSP’s programs within the broader context of educational goals outlined by NASA’s Science Mission Directorate (SMD), demonstrating how RBSP’s outcomes address SMD’s overarching goals to engage Americans in NASA’s mission, attract and retain students in STEM disciplines and strengthen NASA and the nation’s future workforce. The evaluation provides evidence of the E/PO project’s success in achieving other strategic SMD goals including: avoiding duplication of effort and tapping existing dissemination networks; coordinating with key players within NASA Space Science and NASA Education and with interested institutions outside of NASA; involving mission scientists and engineers throughout the effort and reaching out to underserved and underrepresented communities. It demonstrates both quantitative and qualitative metrics for measuring program participants’ change in knowledge, attitudes, behaviors and skills with regard to RBSP science-related content being conveyed by its formal, informal and public outreach efforts.

*Collaboration and Coordination Efforts* The RBSP E/PO team is a fully participating member of the Heliophysics Science Education and Public Outreach Forums (SEPOF), attending monthly SEPOF teleconferences, annual retreats and meetings of opportunity in an effort to share and leverage efforts with members of the NASA Heliophysics E/PO community. RBSP team activities have been highlighted during the SEPOF teleconferences as well on the SMD Heliophysics workspace. In addition to collaboration efforts with the Heliophysics community during the planning, implementation, and follow up of the HEA program, the RBSP team coordinates and participates in multiple NASA E/PO activities. Some of these include: support for NASA’s Sun Earth Day Celebration, participation in NASA’s Explore @ NASA Goddard, participation in Exploration Station alongside other Heliophysics missions such as the Solar Dynamic Observatory, and highlighting NASA’s Heliophysics E/PO program links on the RBSP education webpage. The RBSP E/PO team collaborates with Sten Odenwald of NASA Goddard to create SpaceMath@NASA activities to be placed on the SpaceMath@NASA website, the RBSP website, and distributed directly to educators. We invited team members from NASA centers and universities to participate in the pre-launch teachers workshop and plan to collaborate on the HBCU pre-service teacher workshops. The RBSP exhibit that will be created for the NASA Goddard Visitor Center will be integrated with an existing NASA Heliophysics E/PO display.

*Summary—Making an Impact* The fundamental science research that is being done in the dynamic “laboratory” of the Van Allen Radiation Belts can and will be applied to our study of many other locations and processes throughout the cosmos. The discoveries made during this mission will bolster our understanding of how the universe operates and behaves. Understanding the mysteries and fundamental science of the Van Allen Radiation Belts is also key to our modern way of life: from protecting our current technologies and the health of the people that work in this region of near Earth space, to reaching into the future and building new space based innovations. The E/PO team members and partners strive to share this knowledge through a nationwide program which is based on research and best practices learned from experience working with the education community.

For more information or to become involved in Education/Public Outreach Opportunities please see <http://rbsp.jhuapl.edu/>.

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